

Absolute Geolocation Accuracy Evaluation of TerraSAR-X-1 Spotlight and Stripmap Imagery – Study Results

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Outline

- Objectives
- Product Descriptions and Specifications
- Methodology
- Evaluation Results

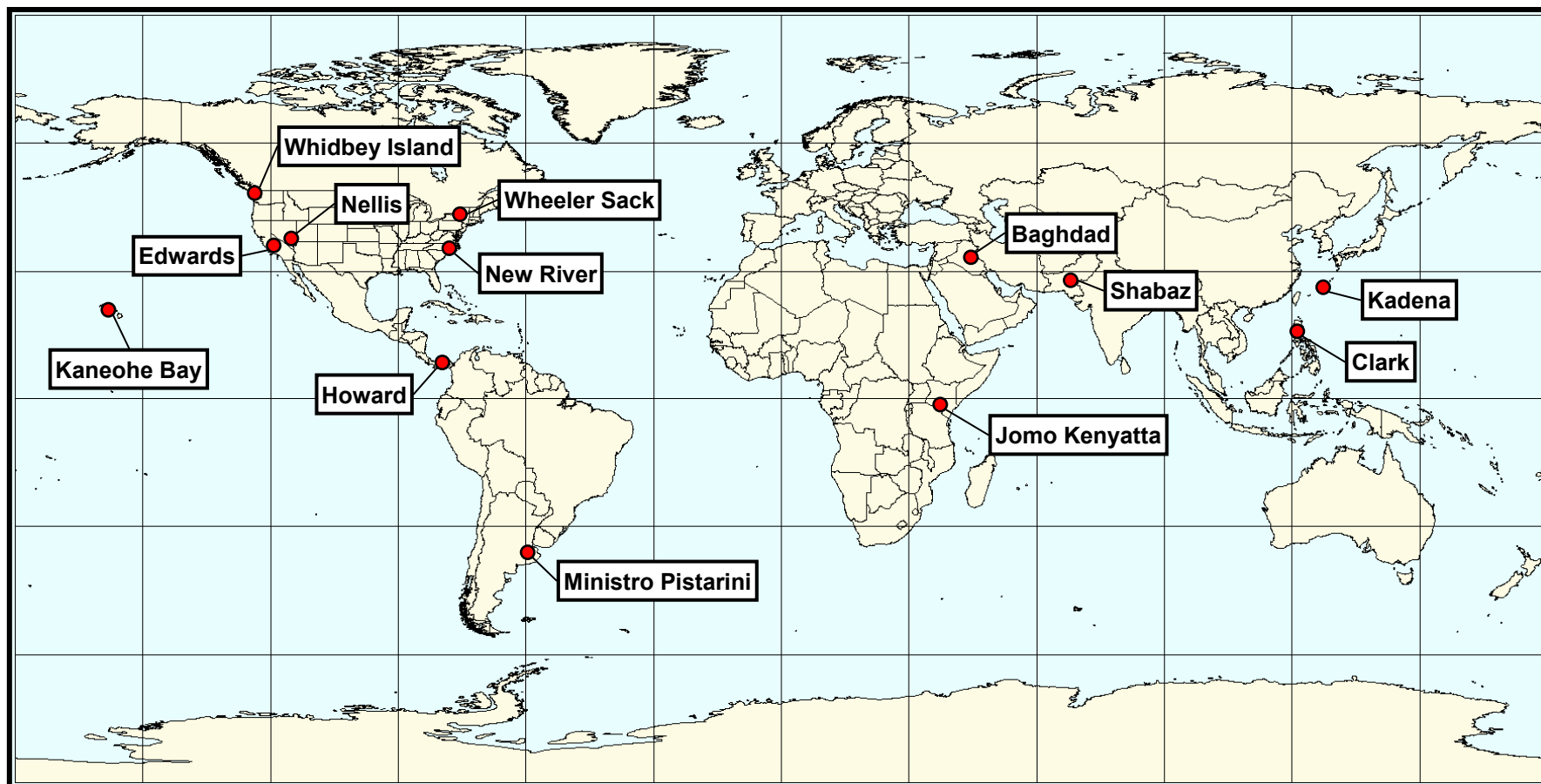


Objectives

- To estimate the absolute horizontal geolocation accuracy from samples of:
 - 13 spotlight mode images
 - 13 stripmap mode images



13 Test Sites for TerraSAR-X-1





Definition of Statistic

- Circular Error 90% (CE90)
 - In horizontal plane
 - Radial error distance centered at zero within which 90% of the data points fall



TerraSAR-X-1

Imagery Products Evaluated

Imaging Mode	Product Pixel Sampling (m)	Ground Resolution (m)	Scene Size (km)	Orbit Type	Geometric Processing	Polarization
High Resolution Spotlight Mode (HS) (300 MHz)	0.5	~1	~7 (Range) x ~5.5 (Azimuth)	Rapid	Spatially-Enhanced (SE) Multi-look Ground-range Detected (MGD)	VV
Stripmap Mode (SM)	1.25	~3	~32 (Range) x ~57 (Azimuth)	Rapid	Spatially-Enhanced (SE) Multi-look Ground-range Detected (MGD)	VV



CCAP Absolute Geolocation Accuracy Methodology

- General Approach: Monoscopic CE90
 - Intersection with ground-surveyed height
- Images are **not** allowed to adjust during evaluation



CCAP Absolute Geolocation Accuracy Methodology

- 1) Load imagery onto workstation with SOCET Set[®]
photogrammetric software**
- 2) Import rigorous sensor model support data
accompanying imagery**



CCAP Absolute Geolocation Accuracy Methodology

3) Compute ground coordinates of checkpoints from test imagery sensor model support data

- Use ground-surveyed control points as checkpoints
- Software continuously projects photogrammetric cursor from 3-dimensional ground coordinate into image using rigorous sensor model and support data
- For each checkpoint:
 - Move to checkpoint ground coordinates (height being ground-surveyed height)
 - Identify checkpoint on image
 - Adjust only horizontal ground position of cursor until at identified checkpoint position on image
 - Record horizontal ground coordinates of checkpoint



CCAP Absolute Geolocation Accuracy Methodology

- 4) For each checkpoint, subtract ground-surveyed coordinates from test-imagery-derived ground coordinates
 - Results in a list of “ Δ Easting” and “ Δ Northing” values



CCAP Absolute Geolocation Accuracy Methodology

5) For each image, compute error centroid

- Compute mean “ Δ Easting” and “ Δ Northing” values
 - Convert into horizontal “ Δ Radial” value
- Additional statistics:
 - Number of checkpoints
 - Maximums & minimums of Δ Easting and Δ Northing values
 - Standard deviations of Δ Easting and Δ Northing values
- Each image represented by single data point for CE90 estimation



CCAP Absolute Geolocation Accuracy Methodology

Each image represented by single data point for CE90 estimation because...

- ...test sites have varying number of checkpoints
 - Challenge for SAR imagery evaluations as many checkpoints are not radar-identifiable
- ...goal of evaluation is to estimate CE90 error statistic for population of images, not individual images



CCAP Absolute Geolocation Accuracy Methodology

6) Estimate CE90

- CCAP uses non-parametric estimator (“Percentile Method”)
- Sort “ Δ Radial” values in ascending order
- Cut-off at 90th percentile
 - For n data points, $0.9*n + 0.5$ defines position in ordered list
 - Linearly interpolate from ordered list as required
- Additional statistics:
 - Number of images
 - Maximums and minimums of centroid values
 - Standard deviations of centroid values



90th Percentile Estimator for Ordered Statistics

Given n ordered data points $x_{(1)}, x_{(2)}, \dots, x_{(n)}$,

where $x_{(i)} = \Delta r_{(i)}$ for CE90.

Then,

$$CE90 = (1 - f) * x_{(i)} + f * x_{(i+1)}$$

where

i = integer part of $0.9 * n + 0.5$, and

f = fractional part of $0.9 * n + 0.5$.



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TerraSAR-X-1 Evaluation Results



TerraSAR-X-1 Spotlight (HS) Mode

Horizontal Accuracy (n=13)

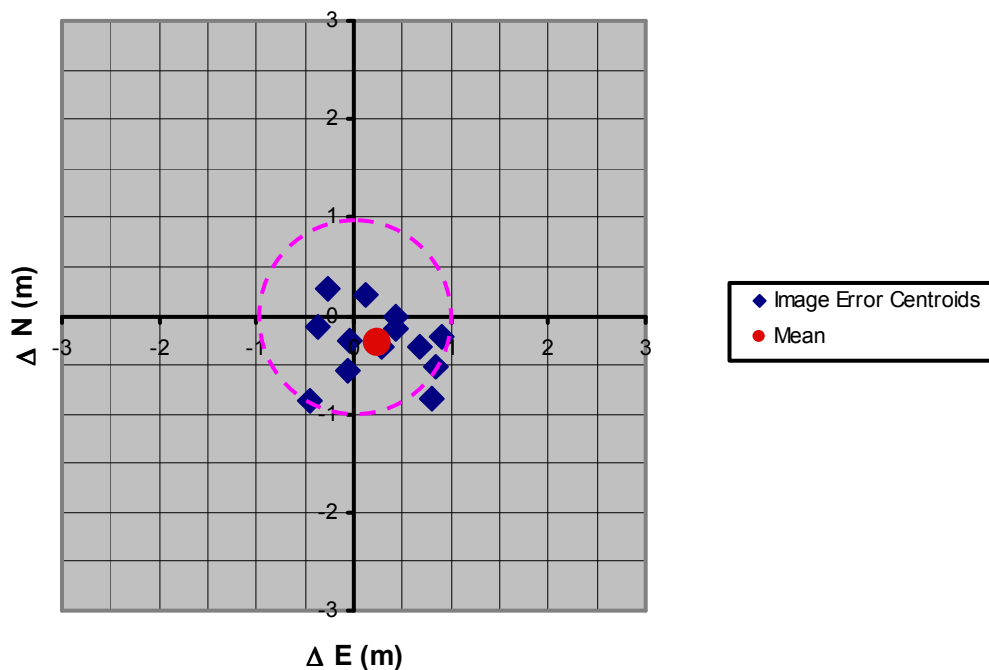
Test Site	CPs	Imagery Date	Mean ΔE (m)	Mean ΔN (m)	Δr (m)
Argentina, Ministro Pistarini	2	31-May-2008	0.8	-0.8	1.2
Iraq, Baghdad	2	13-May-2008	-0.4	-0.9	1.0
Japan, Kadena	14	16-May-2008	0.7	-0.3	0.7
Kenya, Jomo Kenyatta	7	13-May-2008	0.0	-0.2	0.3
Pakistan, Shabaz	10	10-Jun-2008	0.9	-0.2	0.9
Panama, Howard	19	13-May-2008	-0.3	0.3	0.4
Philippines, Clark	7	14-May-2008	0.4	-0.1	0.4
United States, Edwards	10	10-May-2008	-0.1	-0.6	0.6
United States, Kaneohe Bay	6	11-May-2008	0.3	-0.3	0.4
United States, Nellis	5	31-May-2008	-0.4	-0.1	0.4
United States, New River	3	13-May-2008	0.4	0.0	0.4
United States, Wheeler Sack	8	30-May-2008	0.1	0.2	0.2
United States, Whidbey Island	14	15-May-2008	0.8	-0.5	1.0

	Mean ΔE (m)	Mean ΔN (m)	Δr (m)
Mean (m)	0.3	-0.3	0.6
Standard Deviation (m)	0.5	0.4	0.3
Maximum (m)	0.9	0.3	1.2
Minimum (m)	-0.4	-0.9	0.2



TerraSAR-X-1 Spotlight (HS) Mode Horizontal Accuracy (n=13)

TerraSAR-X-1 Spotlight Monoscopic
Absolute Geolocation Accuracy
(Rigorous Sensor Model Data)



Test Site	Sorted Δr (m)
United States, Wheeler Sack	0.2
Kenya, Jomo Kenyatta	0.3
Panama, Howard	0.4
United States, Nellis	0.4
United States, Kaneohe Bay	0.4
United States, New River	0.4
Philippines, Clark	0.4
United States, Edwards	0.6
Japan, Kadena	0.7
Pakistan, Shabaz	0.9
Iraq, Baghdad	1.0
United States, Whidbey Island	1.0
Argentina, Ministro Pistarini	1.2

Estimated Mono CE90 = 1.0 m



TerraSAR-X-1 Stripmap (SM) Mode Horizontal Accuracy (n=13)

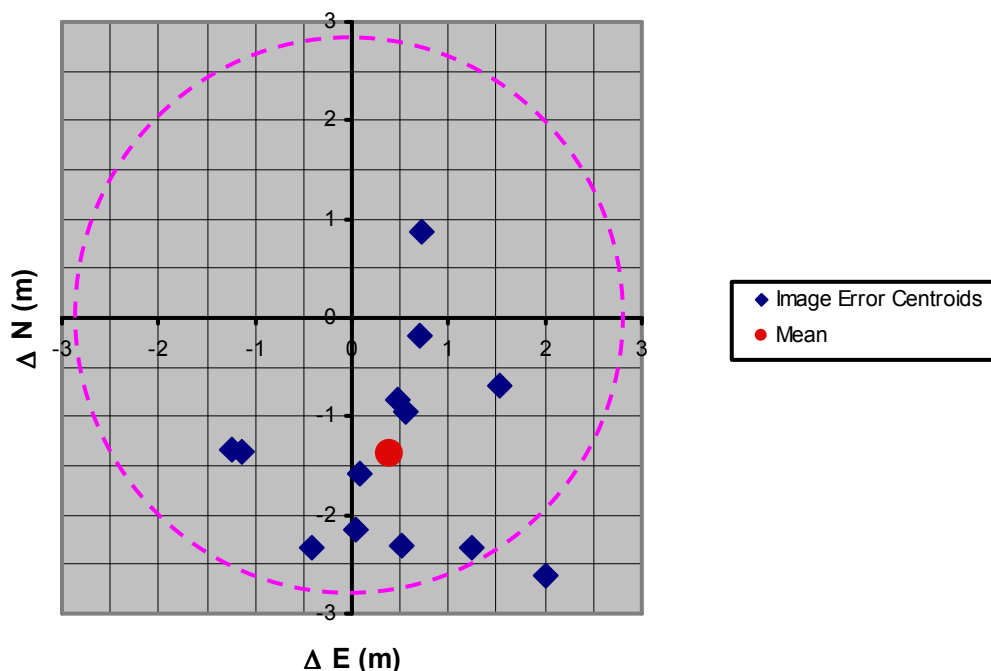
Test Site	CPs	Imagery Date	Mean ΔE (m)	Mean ΔN (m)	Δr (m)
Argentina, Ministro Pistarini	5	25-May-2008	0.0	-2.1	2.1
Iraq, Baghdad	2	24-May-2008	0.5	-2.3	2.4
Japan, Kadena	6	26-May-2008	-1.2	-1.3	1.8
Kenya, Jomo Kenyatta	2	7-Jun-2008	-0.4	-2.3	2.4
Pakistan, Shabaz	5	30-May-2008	1.2	-2.3	2.6
Panama, Howard	12	17-May-2008	1.5	-0.7	1.7
Philippines, Clark	5	14-May-2008	0.7	-0.2	0.7
United States, Edwards	11	1-Jun-2008	0.6	-0.9	1.1
United States, Kaneohe Bay	4	16-May-2008	-1.1	-1.4	1.8
United States, Nellis	4	22-May-2008	2.0	-2.6	3.3
United States, New River	6	23-May-2008	0.7	0.9	1.1
United States, Wheeler Sack	9	23-May-2008	0.5	-0.8	1.0
United States, Whidbey Island	10	23-May-2008	0.1	-1.6	1.6

	Mean ΔE (m)	Mean ΔN (m)	Δr (m)
Mean (m)	0.4	-1.4	1.8
Standard Deviation (m)	0.9	1.0	0.7
Maximum (m)	2.0	0.9	3.3
Minimum (m)	-1.2	-2.6	0.7



TerraSAR-X-1 Stripmap (SM) Mode Horizontal Accuracy (n=13)

TerraSAR-X-1 Stripmap Monoscopic
Absolute Geolocation Accuracy
(Rigorous Sensor Model Data)



Test Site	Sorted Δr (m)
Philippines, Clark	0.7
United States, Wheeler Sack	1.0
United States, Edwards	1.1
United States, New River	1.1
United States, Whidbey Island	1.6
Panama, Howard	1.7
United States, Kaneohe Bay	1.8
Japan, Kadena	1.8
Argentina, Ministro Pistarini	2.1
Kenya, Jomo Kenyatta	2.4
Iraq, Baghdad	2.4
Pakistan, Shabaz	2.6
United States, Nellis	3.3

Estimated Mono CE90 = 2.8 m



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Questions?



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